Numerical Regularization of Ill-Posed Problems via Hybrid Feedback Controls

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Abstract : Many mathematical models used in biological and other applications are ill-posed. The reason for that is the nature of differential equations, where the nonlinearities are assumed to be step functions, which is done to simplify the analysis. Prominent examples are switched systems arising from gene regulatory networks and neural field equations. This simplification leads, however, to theoretical and numerical complications. In the presentation, it is proposed to apply the theory of hybrid feedback controls to regularize the problem. Roughly speaking, one attaches a finite state control (‘automaton’), which follows the trajectories of the original system and governs its dynamics at the points of ill-posedness. The construction of the automaton is based on the classification of the attractors of the specially designed adjoint dynamical system. This ‘hybridization’ is shown to regularize the original switched system and gives rise to efficient hybrid numerical schemes. Several examples are provided in the presentation, which supports the suggested analysis. The method can be of interest in other applied fields, where differential equations contain step-like nonlinearities.

Keywords : hybrid feedback control, ill-posed problems, singular perturbation analysis, step-like nonlinearities
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